ORIGINAL ARTICLE

Passive, Opportunistic Wildlife Disease Surveillance in the Rocky Mountain Region, USA

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Summary

Wild animals can play an important role in the epidemiology of infectious disease with significant public health, economic and ecological consequences. As it is often challenging to conduct unbiased surveillance in free-ranging mammal populations, passive, opportunistic case identification has been widely used for detection of disease events in wild animals. This study evaluated the role of different agencies and organizations in the Rocky Mountain Region of the USA to identify significant wildlife health events or aggregate information from multiple sources. Overall wildlife rehabilitators were in contact with the greatest number of animals; however, the data from these groups, in its current state, are insufficient for surveillance purposes. Wild animal data from all survey groups aggregated at the level of state wildlife organizations; these agencies are therefore central in this type of surveillance activity and require sufficient resources to ensure that appropriate testing is conducted.

Introduction

In recent years, the role of wild animals in the epidemiology of emerging and zoonotic diseases has come under increased scrutiny. Many infectious diseases represent a threat to wild animal populations and biodiversity (Daszak et al., 2001, 2004): free-ranging animal populations can serve as important reservoirs for diseases with substantial public health and economic significance (Daszak et al., 2000; Simpson, 2002; Bengis et al., 2004; Kruse et al., 2004). Despite the importance of this animal group, large gaps remain in our understanding of the behaviour of these pathogens in wild animals and techniques with which to detect and study them.

Disease surveillance is the predefined, systematic collection of health-related data for analysis, interpretation and action to improve health within populations. Such systems are often subclassified based on the method and intensity of data collection which delineates 'active' from 'passive' surveillance. Passive surveillance implies that health-related data collected for other, routine usage is then used within the system whereas active surveillance entails a predefined data collection scheme specific to the objectives of the system. While there exist numerous resources to aid in the design and implementation of surveillance systems in domestic animals, it is inherently more difficult to conduct disease surveillance in wild animals (Morner et al., 2002). Collecting non-biased data on wild animals can be logistically difficult and expensive. Basic population parameters are often unknown for wildlife, making the design and implementation of conventional surveillance techniques difficult. Thus, what is commonly referred to as passive surveillance can often be better described as 'opportunistic' in wild animals.

A key feature of opportunistic surveillance is the detection of a wildlife health event and communication of information to the appropriate individuals. The objective of this study was to identify key groups in positions to detect mammalian wildlife disease events within the Rocky Mountain Region of the USA and recognize pathways by which public health, domestic animal and wildlife surveillance information could be synergized.

Materials and Methods

The study was conducted in the Rocky Mountain Region (Colorado, Wyoming, North and South Dakota, Montana and Utah) as defined by the United States Environmental Protection Agency Region Eight. Organizations thought to be in a position to detect significant health events in wild mammal populations were identified through agency listings, the internet and personal recommendations. Telephone or web-based interviews were conducted to determine the scope of the organization, the frequency of wild mammal interactions, procedures for dealing with wild mammals or related data and the role, or potential role, of the agency in wild mammal disease surveillance in the region. Data were analysed using descriptive statistics and chi-squared tests for comparing frequencies between categories.

Results

Wildlife rehabilitators

Forty-three wildlife rehabilitators that met the inclusion criteria were identified including 30 in Colorado, eight in Utah, two in South Dakota and one in each of Wyoming, Montana, and North Dakota. Of these, interviews were conducted with at least one individual from 27 organizations. All groups were private and non-profit. The focus of all programmes was individual animal rehabilitation; however, some facilities reported public education (19%) and population level wild animal health (7%) to be ancillary objectives.

Facility size, catchment area and record keeping information are presented in Table 1. Individuals interviewed reported that the number of mammals presented to the facility varied widely with season and from year to year. When data or records were used, it was most commonly for sharing with relevant groups including state wildlife agencies (82%), state public health agencies or other rehabilitators. Records were less frequently used to determine trends in presentation such that intake could be predicted, to look up treatment protocols used in the past, or for grant writing or summary reports to donors. The majority (90%) said that they would be willing to share data with groups interested in regional wildlife disease trends.

Only 30% of rehabilitators reported that they regularly test for disease and in most instances, disease testing was overseen by a consulting veterinarian. Mammal species tested most commonly included foxes, deer, raccoons, bats and coyotes. Diseases of concern included rabies, chronic wasting disease (CWD), plague, distemper, parvovirus and various parasites. Eighty-eight per cent of respondents had submitted an animal to a veterinarian for necropsy; however, this was an infrequent occurrence. Rationale for having a necropsy performed included death of unknown causes, potential for human rabies exposure or concern about an infectious disease. Many animals present to rehabilitators with overt lesions consistent with trauma, and in these cases postmortem examination is rarely performed. No rehabilitators had an active, routine sampling scheme or saved potential diagnostic material for future use. Reasons for the infrequency of disease testing included expense, stress on the animal or lack of need.

Table 1. Facility size, radius of service and record keeping information for rehabilitation centers in the Rocky Mountain Region

Facility case load	Percentage of interviewed facilities
Small (<15 mammals/year)	30
Medium (15–50 mammals/year)	33
Large (50–100 mammals/year)	10
Very large (>100 mammals/year)	7
Radius of service (km)	
<50	17
50–250	53
>250	30
Record keeping	
Keep individual animal records (any format)	92
Spreadsheets or database	52
Paper records	43
Computer text documents	4
Animal information recorded*	
Species	100
Sex	96
Age	96
Body condition	91
Animal pick-up location†	87

*Other recorded information included treatment and outcomes, diet, duration at the facility, and contact information for submitter.
†Animal pick-up location was most often recorded by street address, but the format and accuracy were dependent on the discretion and knowledge of the individual submitting the animal.

Overall, 88% of respondents felt that rehabilitators had an important role in wildlife disease surveillance because these facilities see so many animals and represent a 'front line' of emerging disease issues. Other agencies perceived by rehabilitators to play a significant role in wildlife disease surveillance in their region are listed in Table 2. Opinions on the quality of disease surveillance varied widely but a recurring comment was that disease surveillance was driven by public health and production limiting diseases.

Zoos

Six zoos were identified within the geographic area of interest. All but one (83%) reported that they are

Table 2. Agencies or organizations perceived by rehabilitators to be most involved in wildlife disease surveillance in the region (in descending order)

State Wildlife Agency
Health departments
Other rehabilitators
United States Fish and Wildlife Service
Veterinarians
Research groups and Universities
Humane societies
Animal control
Law enforcement
Center for Disease Control
Bureau of Land Management
United States Department of Agriculture

Table 3. Number of outdoor recreation organizations within each group identified, contacted and response rate in the Rocky Mountain Region

Group type	Identified	Contacted	Response (%)
Hunting	328	52	21
Fishing	32	16	44
Outdoor Education	5	5	80
Hiking	19	19	42
River Guides	21	21	38
Wildlife Tours	16	16	13
Total	421	129	31*

*Representing interviews from CO (12), MT (10), WY (8), UT (5), SD (3), and ND (2).

occasionally presented with wild animals from the public, state wildlife agencies or police. Protocols for handling such animals vary by facility but a sick or injured animal may be rehabilitated by the zoo when they are approved for rehabilitation; if not, the animal is under the jurisdiction of state wildlife agencies. Disease testing in wild animals is at the discretion of zoo veterinarians, though some zoos collaborate routinely on infectious disease testing with the Association of Zoos and Aquariums. All respondents reported that they frequently receive phone calls from the public regarding sick or injured wild animals; zoos refer such calls to the state wildlife officials, rehabilitators, or the local humane society. When asked about concerns regarding diseases in wild animals, pathogens of significance to both wildlife and humans were cited including West Nile virus, rabies, CWD, distemper and diseases foreign to their geographic area.

Outdoor recreation groups

Over 400 outdoor recreation groups were identified within the six states. A total of 137 groups were contacted and interviews were completed by 40 individuals. Interviews by category and state are presented in Table 3; there was, however, considerable overlap between categories as many companies offered multiple types of activities.

Individuals were asked about the types of mammals observed when on wilderness trips. Those reported, in order of decreasing frequency, were large ungulates, carnivores and small mammals. Seventy-nine per cent of respondents said that they had seen sick, injured, or dead animals. This number did not differ significantly by activity group ($P = 0.55$), however, most guides from all groups (73%) reported that such findings were rare. Mortality events observed were most often attributed to road kill; however, respondents also noted having seen cases of presumed epizootic haemorrhagic disease in deer, predation and gunshot deaths.

Directed actions taken by outdoor adventure personnel were influenced by the location of the observation and the presumed severity of what they had seen. Sixty-seven per cent of responders reported that they would take some action based on their observations; this frequency did not vary by activity group ($P = 0.17$). The most common action (71%) was reporting the observation of sick, dead or injured wildlife: the majority (64%) of individuals interviewed said that they would report events to the state wildlife organization. Government land management agencies were also mentioned, as well as rehabilitators and highway patrol. Remaining individuals that would take action based on observations said that they would either attempt to help or shoot a sick or severely injured animal.

When asked if they had concerns regarding infectious diseases in wild animal populations, 51% of total respondents reported that they were concerned. However, 32% of these people said that their concerns were only mild or specific to some diseases or species. Concerns regarding disease in wild populations did not differ by activity class ($P = 0.56$). Reported disease issues focused on the health of wild populations in general but included diseases with public health significance and the potential loss of income given the inherent relatedness of their profession to ecosystem health.

Private veterinary practitioners

The overall response rate was 4% and did not vary by state ($P = 0.50$); survey responses by state and practice type are presented in Table 4. Overall, veterinary clinics reported that they were presented with wild animals very rarely (56%) or never (21%). However, 21% of clinics reported that they saw wild animals on a monthly basis. The frequency with which wild animals were presented to clinics did not vary by state ($P = 0.69$), although wild animals were presented to small and mixed animal

Table 4. Response rate and veterinary clinic type by state

State	Surveys mailed	Surveys returned (%)	Clinic type (%)
Colorado	576	21 (4)	Small animal predominantly (57) Mixed animal (29) Large animal predominantly (9) Other (5)
Utah	169	9 (5)	Small animal predominantly (33) Mixed animal (56) Other (11)
Wyoming	107	4 (4)	Small animal predominantly (75) Mixed animal (25)
North Dakota	98	4 (4)	Small animal predominantly (25) Mixed animal (50) Large animal predominantly (25)
South Dakota	180	6 (3)	Small animal predominantly (25) Mixed animal (75)
Montana	239	8 (3)	Small animal predominantly (60) Mixed animal (40)

practices significantly more often than large animal practices ($P = 0.01$). Wild animals were brought to veterinarians most often in the spring and summer. Rabbits, raccoons, skunks, bats and squirrels were the most commonly reported small or medium sized animals. Large animals included antelope, deer, elk, moose, bear and mountain lion. Turtles and a variety of wild fish species were reportedly presented to small and mixed animal clinics and the single aquatic animal veterinarian respectively.

Forty per cent of the clinics had protocols in place for dealing with wild animals; this did not differ by type of clinic ($P = 0.52$) or by state ($P = 0.77$). Within clinics, protocols varied by species and health status of the animal, though if not euthanized, animals were most commonly (73%) transferred to a licensed rehabilitator or the state wildlife agency. Procedures for transferring wild animals did not vary between state ($P = 0.57$) or type of clinic ($P = 0.85$).

Only 40% of responding veterinary clinics kept records on wildlife. Information collected and method of recording is presented in Table 5. Veterinary clinics reported that data were rarely used unless specifically requested by a wildlife health agency, which was reported to occur on a case by case basis: 35% of clinics reported that they had shared clinical information with a regulatory or wildlife health agency in the past. Sixty-one per cent of clinics reported that they would be willing to share data with wildlife health-related agencies and the remaining 39% were unsure. Many respondents commented that information sharing would depend on available time and resources. When veterinary clinics received phone calls regarding sick or injured wildlife they either referred the caller to state wildlife agencies, animal control officers, public health, rehabilitators, humane societies, or tried to answer the question themselves.

Table 5. Information and format of data collected on wild animals presented to veterinary clinics

Record keeping	Percentage of responding clinics
Species	96
Age	60
Gender	70
Body condition	70
Location found	81
Clinical examination findings	89
Pathological findings	70
Other information: treatment or specific pathogen testing	
Paper records	93*
Spreadsheet or database	7*
Electronic medical records	30*

*Information often recorded in multiple locations.

Veterinarians were asked about the frequency of testing wildlife for specific diseases including rabies, West Nile virus, distemper, influenza, plague, tularaemia or other agents. Forty-seven per cent of respondents had tested for one or more of these or other diseases; most tests were sent out to state wildlife agencies, state diagnostic laboratories, state public health departments, and, rarely, private diagnostic laboratories. The rationale for testing included public health surveillance (77%), general disease awareness (20%), emerging disease surveillance (11%) and disease prevalence assessment (9%). Veterinarians felt that findings of diagnostic testing led to an active response in 58% of the cases. Responses reported included individual post-exposure vaccination (rabies) and public health recommendations.

When asked about the role of private practice veterinarians in wildlife disease surveillance, 63% reported that veterinarians are central in the identification of important health events and can route information to the appropriate group, 14% said that veterinary clinics have little or no role, 10% believed that a veterinarian's role is individual animal care and diagnosis, 6% reported that veterinarians could play a role as needed and the remaining 5% felt that a veterinarian's role in wildlife disease is public service and education. Reported limitations to veterinary involvement included the lack of financial compensation for testing and shipping of samples, the lack of simple, standardized information reporting protocol and failure to obtain continuing education credits for any ancillary training in wildlife disease issues. When asked who they perceive to be most involved in regional wildlife disease surveillance, 74% of veterinary clinic respondents identified state wildlife agencies.

Veterinary diagnostic laboratories

Eight veterinary diagnostic laboratories within the geographic interest area were identified and interviewed. Two laboratories were private, international, fee-for-service companies that only conduct tests at the request of veterinarians and do no record keeping or disease reporting. The remaining laboratories represent fee-for-service veterinary diagnostic laboratories offering diagnostic services and participating in contract research; most were associated with a university or state animal health organization. A single laboratory is present within each state, though testing is not restricted to in-state animals.

The number of wild animal cases presented to diagnostic laboratories varied throughout the year but usually weekly or monthly, except Wyoming, where a regular, daily case load of wild animals was reported. Species represented was equally variable; however, many laboratories reported an apparent over-representation of mammals, species specifically known to harbour certain pathogens, or large, charismatic species. Four of the six laboratories have specific personnel with wildlife interest. Diagnostic tests most commonly performed vary by region and species examined. At all laboratories, requested tests are sent out to other agencies if they cannot be performed in-house. Minimum duration of sample storage varies by laboratory; most laboratories hold fixed tissues, slides and paraffin blocks for 4–10 years while fresh/frozen tissue is routinely stored for 1–2 months. Cases of interest to the submitter, laboratory or relevant to any legal action can be held indefinitely; tissues from all wild animals submitted to Wyoming State Veterinary Laboratory are held indefinitely. Space was the most commonly cited limitation to tissue storage. All laboratories use a computer database, sometimes in conjunction with paper records; electronic records may be stored indefinitely. Test results are reported directly to the submitter and laboratory data are shared with relevant governmental agencies when deemed necessary, such as in the case of foreign animal diseases. Issues surrounding the sharing of wildlife disease information were focused on client confidentiality and logistics of information transfer.

The role of regional diagnostic laboratories in wildlife disease surveillance or outbreak investigation is largely to provide diagnostic support to lead agencies coordinating the effort; this involves collaboration to determine the most appropriate approach to meet the objectives of the programme. Individuals interviewed identified state wildlife agencies as the most important group involved in regional wildlife disease surveillance. Other agencies noted included the federal wildlife groups and state agriculture agencies.

State public health departments

For each state, a single individual was identified for interview. All interviewees were within the state public health department; however, only two states, North Dakota and Wyoming, have a veterinarian employed to work on health issues affecting animals and humans. The mandate of all state public health departments focuses on humans; wildlife only factors in when it is identified as a potential risk to humans, specifically as an infectious disease reservoir. All states monitor diseases found in wild animal populations, however, all respondents reported that their involvement in identification, diagnosis and information management pertaining to these diseases was minimal. While two states reported that the public health agency will harvest tissues for diagnostic testing specific to reportable diseases, remaining states had sampling done at veterinary diagnostic laboratories. Information pertaining to disease in wild mammals was primarily managed by state wildlife agencies and provided to the public health department when needed. Many individuals interviewed identified this duplication of records as redundant.

Conclusion

Of the groups surveyed within the Rocky Mountain Region, wildlife rehabilitators have the most contact with sick or injured wildlife and thus may serve as a good source for information and diagnostic material. However, there are overt limitations to the usefulness of this passive data source. In general, young animals and certain species are over-represented for rehabilitation and facilities are not uniformly distributed, resulting in biased samples. While the majority of rehabilitators interviewed were willing to share information and participate in disease surveillance programmes, the paucity of diagnostic testing and largely unsearchable nature of individual animal health records restrict the usefulness of these data for surveillance purposes. Conditions impacting willingness to participate included time and resource investment and agreement on the use of data; those respondents unwilling to share data from their facilities cited distrust of recipients and concern that it would require too much effort. Many rehabilitators cited insufficient funding and veterinary support as limitations to the amount of disease testing that could be performed. These limitations have been observed in other studies that also identified rehabilitators as an important resource for wildlife health information (Stitt et al., 2007); tools to overcome these obstacles are required before these data can be aggregated for emerging disease trend identification.

Zoological parks have recently been identified as possible sentinels for emerging disease events given their diverse animal populations with variable susceptibilities, close observation and increased ease of handling, serial sampling opportunities and archived samples (Ludwig et al., 2002; Chomel and Osburn, 2006). The six zoos identified within the Rocky Mountain region worked closely with veterinarians and kept detailed records and sample banks on collection animals, however, the frequency with which they dealt with free-ranging wild mammals was rare. All zoos reportedly worked closely with state wildlife agencies and therefore information pertaining to health events in free-ranging animal populations would be conveyed to the state level quickly.

The role of private veterinary clinics in wildlife disease surveillance is negligible. Over three-quarters of the clinics responded that they very rarely or never see sick or injured wild animals and of those that did, only 40% kept records, making veterinary clinics poor sources for cases or information. Clinics referred wild animal cases to rehabilitators and state wildlife agencies, suggesting that these groups represent a more efficient target for surveillance efforts. These results are consistent with other studies where over 70% of veterinarians surveyed reported that they had limited involvement with wild animals and that most re-directed cases to wildlife rehabilitators (Stitt et al., 2007). The response rate of veterinarians in this survey was low. Opportunistic follow-up with local practitioners suggested that many individuals have so little involvement with wild animals that they felt their responses would be worthless; therefore, the findings of this study may actually over-represent the involvement of veterinarians in wildlife disease surveillance. While many respondents reported that they believed veterinarians are important in wildlife health events in general, lack of funding, lack of information on diseases harboured in free-ranging animals, difficulty in sampling and shipping and insufficient data collection protocols were cited as limitations on their involvement.

Outdoor recreation personnel expressed an interest and concern for diseases in wild animal populations; however, the frequency with which they encounter sick, injured or dead animals is low and tends to be skewed towards larger, charismatic species. While they were beyond the scope of this project, other individuals who may be in a similar position as outdoor recreation personnel to observe wildlife health events would be rural landowners and farmers. Such individuals often have a great deal of local ecology knowledge and may identify changes in animal patterns. The identification of any potentially significant health events by this group would be reported to the state wildlife agency. Likewise, state public health agencies and veterinary diagnostic laboratories play an important role in wildlife disease surveillance by conducting diagnostic testing; however, these laboratories largely provide support to state wildlife agencies and thus data from the laboratory infrastructure are most likely captured by state wildlife officials.

Overall, state wildlife agencies were the most commonly cited groups for aggregation of wildlife health-related information in the Rocky Mountain Region and should therefore play a key role in the identification of events that may represent a threat to public health, domestic animals or biodiversity. These agencies must therefore be equipped with, or have access to, the personnel and resources necessary to quickly and effectively respond to wildlife health events and tools to analyse state wildlife health information for surveillance purposes. Postmortem examination of dead animals has long been a mainstay of wildlife disease surveillance; it is an inexpensive means to gain insight into specific causes of mortality, however, it requires that individuals have extensive training in wildlife pathology (Leighton et al., 1997; Morner et al., 2002). Investigation into wildlife health events is further complicated by the fact that veterinary diagnostic modalities are rarely tested or validated in wild animals and interpretation of findings can be challenging. While an evaluation of state wildlife groups was beyond the scope of this project, cursory review of staff listings identified veterinarians within state wildlife agencies in only three states and no reference to individuals with specialty training in pathology. Most diagnostic laboratories interviewed expressed a strong interest in working with state wildlife agencies; however, this can be logistically difficult given geographic separation of some groups. Wyoming State Veterinary Laboratory is an exception, as state wildlife personnel are housed in the same location fostering regular communication and collaboration.

Identification of cases within a passive system is influenced by the willingness of individuals to participate, awareness or detection pressure for the disease, clinical manifestation and fatality rates, knowledge and education, and the availability of a diagnostic laboratory to diagnose or confirm cases. It is logistically difficult to recover sick and dead wild animals, as has been exemplified in experimental studies evaluating carcass recovery and mortality estimates (Wobeser and Wobeser, 1992). Mass mortality events are likely to be detected and reported by biologists or the public; however, these events represent only a fraction of mortality in wild animals (Morner et al., 2002). Given the difficulty of identifying health-related events in small and inconspicuous species, systematic trapping or other techniques would need to be employed. Information reporting and submissions to laboratories are increased when infrastructure facilitating delivery of the animal or tissue is optimized.

In conclusion, within the Rocky Mountain Region, state wildlife agencies appear to be the key node for opportunistic surveillance data. Should state-level passive surveillance programmes for the identification of emerging health events in wild animal populations remain the primary tool for detection of emerging infectious diseases, wildlife health agencies require sufficient resources to support and train personnel. These agencies should be evaluated to determine the effectiveness of data collection, analysis, interpretation, dissemination and collaboration of this information.

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